

A Thesis Submitted for a PhD degree at ASU

by

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A Dissertation Presented in Partial Fulfillment  
of the Requirements for the Degree  
Doctor of Philosophy

Approved July 2023 by the  
Graduate Supervisory Committee:

Jane Smith, Chair(s)  
Joe Bloggs  
So-and-so

ARIZONA STATE UNIVERSITY

May 2023



## ABSTRACT

The abstract should outline the main approach and findings of the thesis and must not be more than 500 words.

## DEDICATION

To Sun Devils

## ACKNOWLEDGMENTS

I would like to thank my pet goldfish for ...

In accordance with Chapter 7.1.4 of the research degrees handbook, if you have engaged the services of a professional editor, you must provide their name and a brief description of the service rendered. If the professional editor's current or former area of academic specialisation is similar your own, this too should be stated as it may suggest to examiners that the editor's advice to the student has extended beyond guidance on English expression to affect the substance and structure of the thesis.

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You may also wish to acknowledge significant and substantial contribution made by others to the research, work and writing represented and/or reported in the thesis. These could include significant contributions to: the conception and design of the project; non-routine technical work; analysis and interpretation of research data; drafting significant parts of the work or critically revising it so as to contribute to the interpretation.

## Chapter 1

### INTRODUCTION

This is where you introduce the main ideas of your thesis, and an overview of the context and background.

In a PhD, Chapter 2 would normally contain a literature review. Typically, Chapters 3–5 would contain your own contributions. Think of each of these as potential papers to be submitted to journals. Finally, Chapter 6 provides some concluding remarks, discussion, ideas for future research, and so on. Appendixes can contain additional material that don't fit into any chapters, but that you want to put on record. For example, additional tables, output, etc.

#### 1.1 Quarto

In this template, the rest of the chapter shows how to use quarto. The big advantage of using quarto is that it allows you to include your R or Python code directly into your thesis, to ensure there are no errors in copying and pasting, and that everything is reproducible. It also helps you stay better organized.

For details on using Quarto, see <http://quarto.org>.

#### 1.2 Data

Included in this template is a file called `sales.csv`. This contains quarterly data on Sales and Advertising budget for a small company over the period 1981–2005. It also con-

tains the GDP (gross domestic product) over the same period. All series have been adjusted for inflation. We can load in this data set using the following code:

```
sales <- readr::read_csv(here::here("data/sales.csv")) %>%
  rename(Quarter = `...1`) %>%
  mutate(
    Quarter = as.Date(paste0("01-", Quarter), "%d-%b-%y"),
    Quarter = yearquarter(Quarter)
  ) %>%
  as_tsibble(index = Quarter)
```

New names:

Rows: 100 Columns: 4

-- Column specification

----- Delimiter: "," chr

(1): ...1 dbl (3): Sales, AdBudget, GDP

i Use `spec()` to retrieve the full column specification for this data. i

Specify the column types or set `show\_col\_types = FALSE` to quiet this message.

\* `` -> `...1`

Any data you use in your thesis can go into the data directory. The data should be in exactly the format you obtained it. Do no editing or manipulation of the data prior to including it in the data directory. Any data munging should be scripted and form part of your thesis files (possibly hidden in the output).

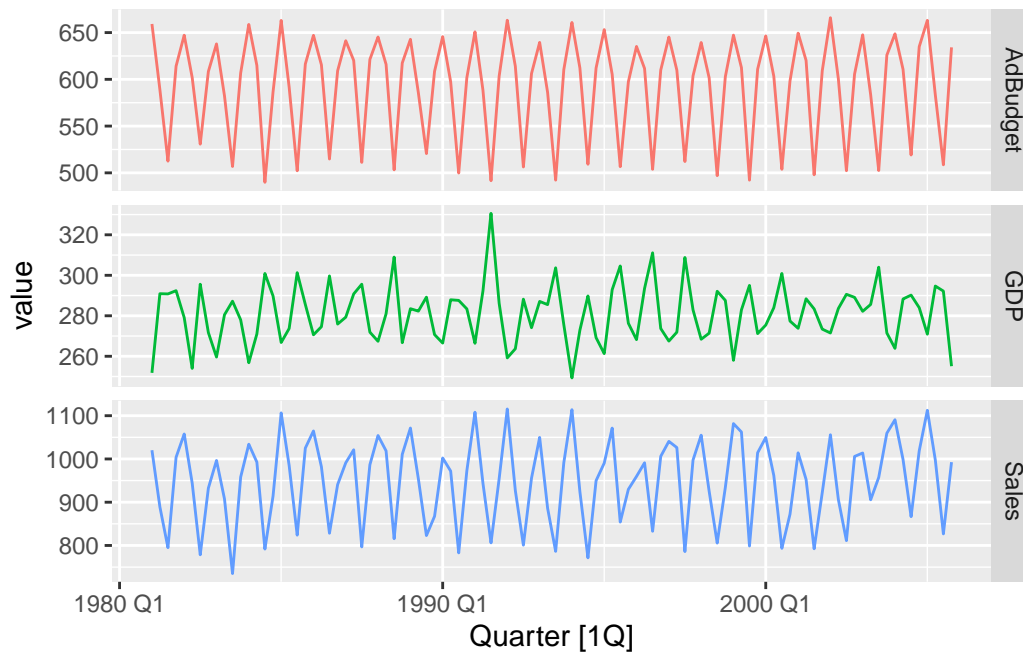


Figure 1. Quarterly sales, advertising and GDP data.

### 1.3 Figures

Figure 1 shows time plots of the data we just loaded. Notice how figure captions and references work. Chunk names can be used as figure labels with `fig-` prefixed. Never manually type figure numbers, as they can change when you add or delete figures. This way, the figure numbering is always correct.

### 1.4 Results from analyses

We can fit a dynamic regression model to the sales data.

Series: Sales

Model: LM w/ ARIMA(1,0,0)(0,1,1)[4] errors



Coefficients:

	ar1	sma1	GDP	AdBudget
	0.2189	-0.9016	0.9742	2.2824
s.e.	0.1022	0.0715	0.4387	0.3930

sigma^2 estimated as 1677: log likelihood=-493.94

AIC=997.87 AICc=998.54 BIC=1010.69

If  $y_t$  denotes the sales in quarter  $t$ ,  $x_t$  denotes the corresponding advertising budget and  $z_t$  denotes the GDP, then the resulting model is:

$$y_t - y_{t-4} = \beta(x_t - x_{t-4}) + \gamma(z_t - z_{t-4}) + \phi_1(y_{t-1} - y_{t-5}) + \Theta_1 \varepsilon_{t-4} + \varepsilon_t \quad (1.1)$$

where  $\beta = 2.28$ ,  $\gamma = 0.97$ ,  $\phi_1 = 0.22$ , and  $\Theta_1 = -0.90$ . We can reference this equation using Equation 1.1.

## 1.5 Tables

Let's assume future advertising spend and GDP are at the current levels. Then forecasts for the next year are given in Table 1.

Table 1. Forecasts for the next year assuming Advertising budget and GDP are unchanged.

Quarter	Sales forecast
2006 Q1	1000.2
2006 Q2	1013.1
2006 Q3	1076.7
2006 Q4	1003.5

Again, notice the use of labels and references to automatically generate table numbers.

## THIS IS A CHAPTER-LEVEL HEADING

### 2.1 This is the first section-level heading

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2.1.1.1.1.1 This is the first sub-paragraph-level heading

## 2.2 Citation examples

The contents of this section differ depending on the bibliography settings, specifically whether the ‘usebiblatex’ toggle is set to ‘true’ or ‘false’. This sentence shows citation with natbib (Pathak et al. 2007). This is another sentence showing citation with natbib (Searchinger et al. 2013).

## 2.3 Footnote examples

This is a sentence followed by a footnote.<sup>1</sup> This is another sentence followed by a footnote.<sup>2</sup>

## 2.4 Block quote example

The following is a block quote:

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<sup>1</sup>Mauris ut leo. Cras viverra metus rhoncus sem. Nulla et lectus vestibulum urna fringilla ultrices. Phasellus eu tellus sit amet tortor gravida placerat. Integer sapien est, iaculis in, pretium quis, viverra ac, nunc. Praesent eget sem vel leo ultrices bibendum. Aenean faucibus. Morbi dolor nulla, malesuada eu, pulvinar at, mollis ac, nulla.

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## 2.5 Endnote examples

Endnotes appear in a separate section after chapters and before the reference list. This is a sentence followed by an endnote. This is another sentence followed by an endnote. And here is a really long endnote to show formatting across several pages.

## 2.6 Table example

See Table 2 for an example of a table. Citing another reference in caption is also straightforward. See Table 3 for a demonstration.

Table 2. Here is a table caption that is especially long to show what happens when it extends to more than one line in the table of contents

Column1	Column2	Column3
Row1	1.0	2.0
Row2	2.0	4.0
Row1	3.0	6.0

Table 3. This table caption refers to another caption: see Figure 2.

Column1	Column2	Column3
Row1	1.0	2.0
Row2	2.0	4.0
Row1	3.0	6.0

Table 4. This table caption refers to another caption: see Figure 2.

Column1	Column2	Column3
Row1	1.0	2.0
Row2	2.0	4.0
Row1	3.0	6.0

## 2.7 Figure example

See Figure 2 for an example of a figure.

## 2.8 Math examples

This section contains some math-heavy text adapted from Wilkins (1995). In non-relativistic wave mechanics, the wave function  $\psi(\mathbf{r}, t)$  of a particle satisfies the Schrödinger Wave Equation

$$i\hbar \frac{\partial \psi}{\partial t} = \frac{-\hbar^2}{2m} \left( \frac{\partial^2}{\partial x^2} + \frac{\partial^2}{\partial y^2} + \frac{\partial^2}{\partial z^2} \right) \psi + V\psi.$$

It is customary to normalize the wave equation by demanding that

$$\iiint_{\mathbf{R}^3} |\psi(\mathbf{r}, 0)|^2 dx dy dz = 1.$$

A simple calculation using the Schrödinger wave equation shows that

$$\frac{d}{dt} \iiint_{\mathbf{R}^3} |\psi(\mathbf{r}, t)|^2 dx dy dz = 0,$$

and hence

$$\iiint_{\mathbf{R}^3} |\psi(\mathbf{r}, t)|^2 dx dy dz = 1$$



Figure 2. *Antidorcas marsupialis*, male



for all times  $t$ . If we normalize the wave function in this way then, for any (measurable) subset  $V$  of  $\mathbf{R}^3$  and time  $t$ ,

$$\iiint_V |\psi(\mathbf{r}, t)|^2 dx dy dz$$

represents the probability that the particle is to be found within the region  $V$  at time  $t$ .

## BIBLIOGRAPHY

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Wilkins, David R. 1995. *Getting Started with LaTeX*. 2nd ed. <http://www.maths.tcd.ie/~dwilkins/LaTeXPrimer/>.

## Appendix A

### ADDITIONAL STUFF

You might put some computer output here, or maybe additional tables. It is possible to have multiple appendices. Just list them in the appropriate place within `_quarto.yml`.

## NOTES

## REFERENCES

## BIOGRAPHICAL SKETCH

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